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SIMULATING REALITY

State of Information Technology in Manufacturing

NIST

Information Technology for Engineering and Manufacturing Conference

June 12, 2000

Gene Allen

Director, Collaborative Development

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OUTLINE

- Basis for Perspective
- Leading Edge Implementations of IT
- Keys to Expanding Use of IT

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Basis for Perspective

- **MSC Business**
  - **Simulation of Physics**
  - **Largest CAE company**
- **Role of Collaboration at MSC**
  - **Interface with Customers**
  - **Interface with Suppliers**

Established Aerospace Customers

Selected Automotive Customers

Collaborative R&D Program Leverage

- **Next Generation CAE Technology is Designed and Developed with Major Customers.**
- **They reduce the Time it Takes to Transfer New Technology from R&D into Production.**
- **They reduce Market Risk and Initial Cost. MSC has helped originate over 100M in Collaborative Programs in the Last Five Years.**

Leading Edge Implementation of IT

- **Infrastructure**
  - **Computational Capabilities – IC's**
  - **Communications – WWW**
- **Content**
  - **Process Understanding**
  - **Interoperability**
- **Pilots**
  - **AIMS**
  - **RDCS**

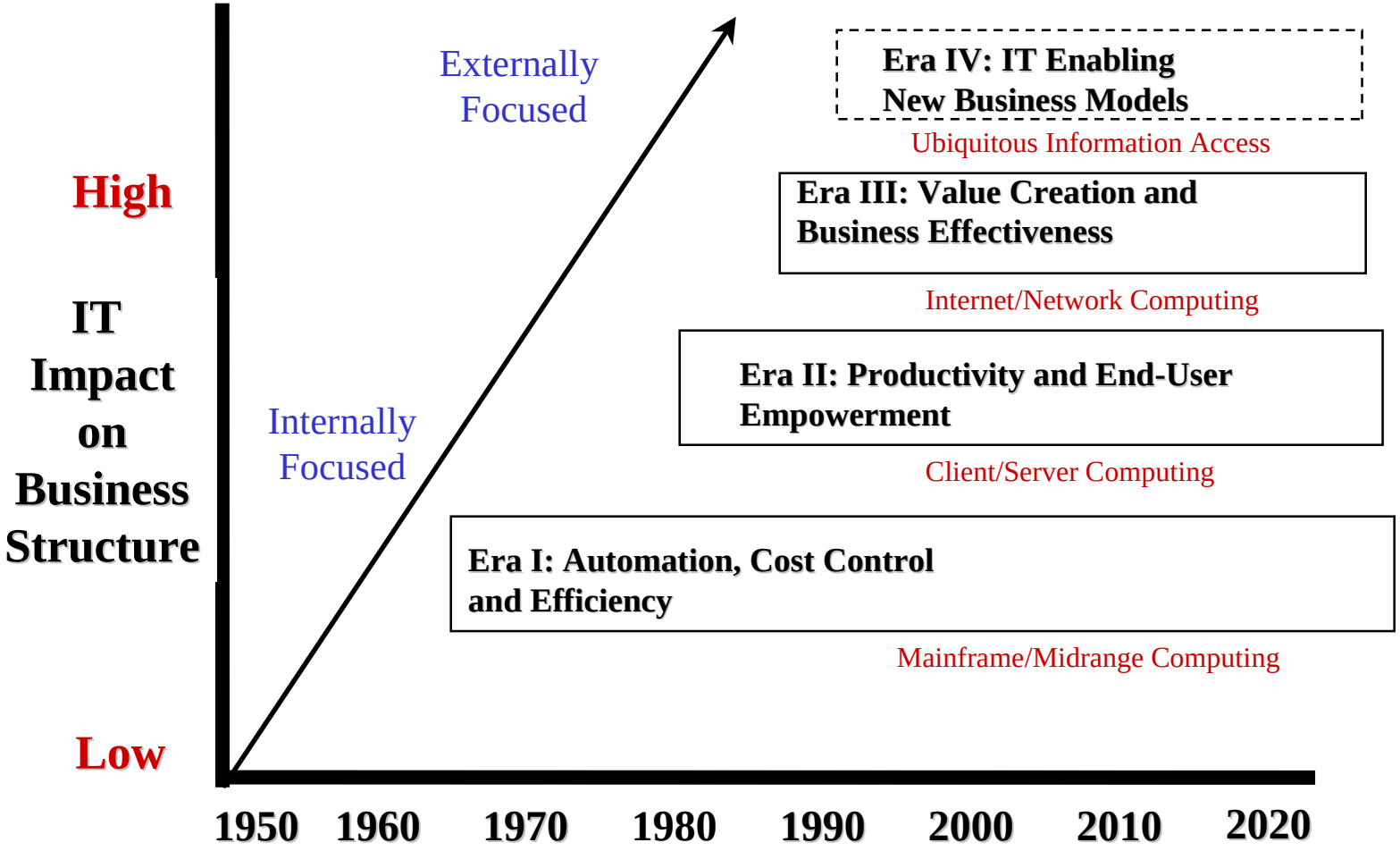
SILICON VALLEY GROUP
OPTICAL LITHOGRAPHY PRODUCT ROADMAP

FIRST DEVICE SHIPMENT	year	1999	2002	2005	2008	2011	2014
TECHNOLOGY GENERATION	nm	180	130	100	70	50	30
PROCESSOR SPEED	MHz	1250	2100	3500	6000	10000	16900
ENABLING TECHNOLOGY		248nm Lamp	248nm Laser	193nm Laser	157nm Laser	EUV Plasma	

SVG came from Perkin-Elmer. They are funded by Intel, AMD, and Motorola to ensure the infrastructure for silicon chip manufacturing is in place. Noreen Harned Presentation at 1/14/00 Defense Science & Technology Seminar on Emerging Technologies: The Roadmap for Tools to 25nm Lithography

IT's Changing Destiny

Evolving IT's Investment Drivers and Technology Cycles



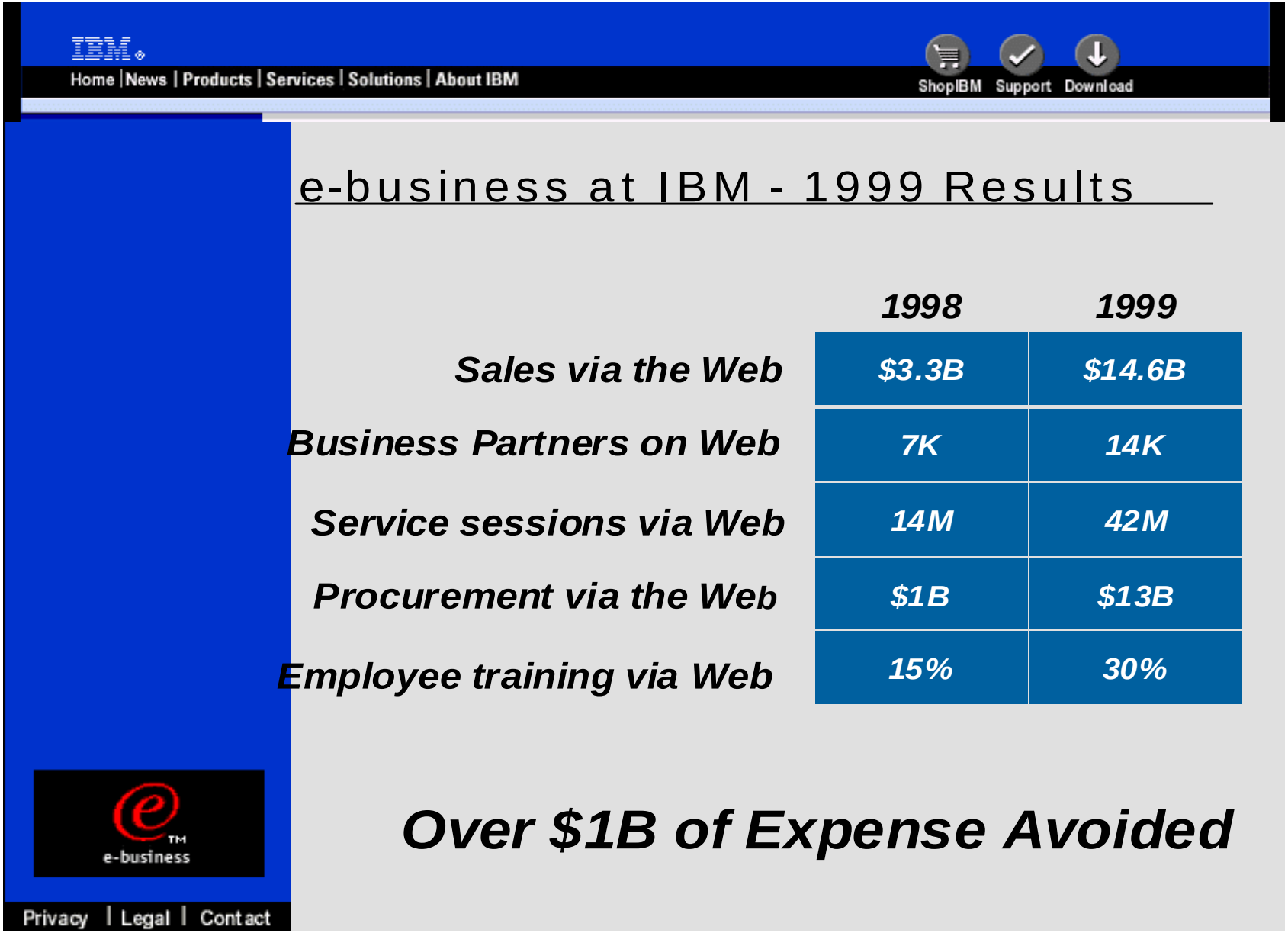
Source. GartnerGroup

B2B Market Estimates for 2004

- Forrester Research - $2.7 Trillion (US only)
- Yankee Group - $2.78 Trillion (US only)
- Gartner Group - $7.3 Trillion (worldwide)

"B2B e-commerce is much larger and growing much faster than business-to-consumer e-commerce." Gary Quick, AIAG Loaned Executive from Ford

Growth in e-business Example



The “e-Business” Supply Chain (Aberdeen Group whitepaper)

… the winners in this new economy will be those companies that can effectively leverage the Internet to redesign, automate, and integrate all business operations - from demand capture, production planning, and purchasing to deliver, customer service, and new product development.”

e-Business Supply Chain

- Be built on an Internet computing architecture
- Enable universal self-service access
- Support demand-driven business procedures
- Provide a common data model for the entire supply chain
- Enable extensive reporting, analysis, and planning
- Support integration with vital business systems
- Provide an open platform for communication, transactions, and collaboration across the entire supply chain
- Deliver modular or component-based solutions

Aerospace

- Boeing, Lockheed Martin, BAE Systems, and Raytheon - an Internet trading exchange for the global aerospace and defense industry
  - Based on CommerceOne MarketSite portal; equal ownership in new entity;
- Others (services, parts)
  - Boeing - myboeingfleet.com
  - UTC - myaircraft.com
  - …..

Automotive
“Covisint”

- GM, Ford, DaimlerChrysler, Renault and Nissan
- Covisint
  - Co - connectivity, collaboration, communication
  - vis - visibility (Internet), vision (supply chain mgmt.)
  - int - integration, international
- Will be established as an independent company
- Oracle and Commerce One are the two primary technology providers to the planned venture

Potential Roadblock

- Federal Trade Commission and the Dept. of Justice hosting a 2 day conference (6/29,30) to discuss the broad ramifications of the exchange.

"The trading exchanges are coming, and suppliers had better prepare," says one FTC antitrust expert. "I wish you all the best of luck with your new life." *Manufacturing News 5/26*

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PROCESS

DEFINITION: a series of actions or operations conducing an end

PROCESSES ARE:

- **DYNAMIC**
- **GOVERNED BY LAWS:**
  - **PHYSICS**
  - **SOCIAL LAW/CULTURE**
  - **MARKET**

THEORY AND PRACTICE CAN DIFFER

The Importance of Process

- 1954- Ray Kroc goes to McDonald's
- Amazed- so many people are served so quickly
- Proposes opening up several restaurants
- 1955 - opens Des Plaines restaurant
- First day's revenues-$366.12, $36B in '98

The Importance of Process

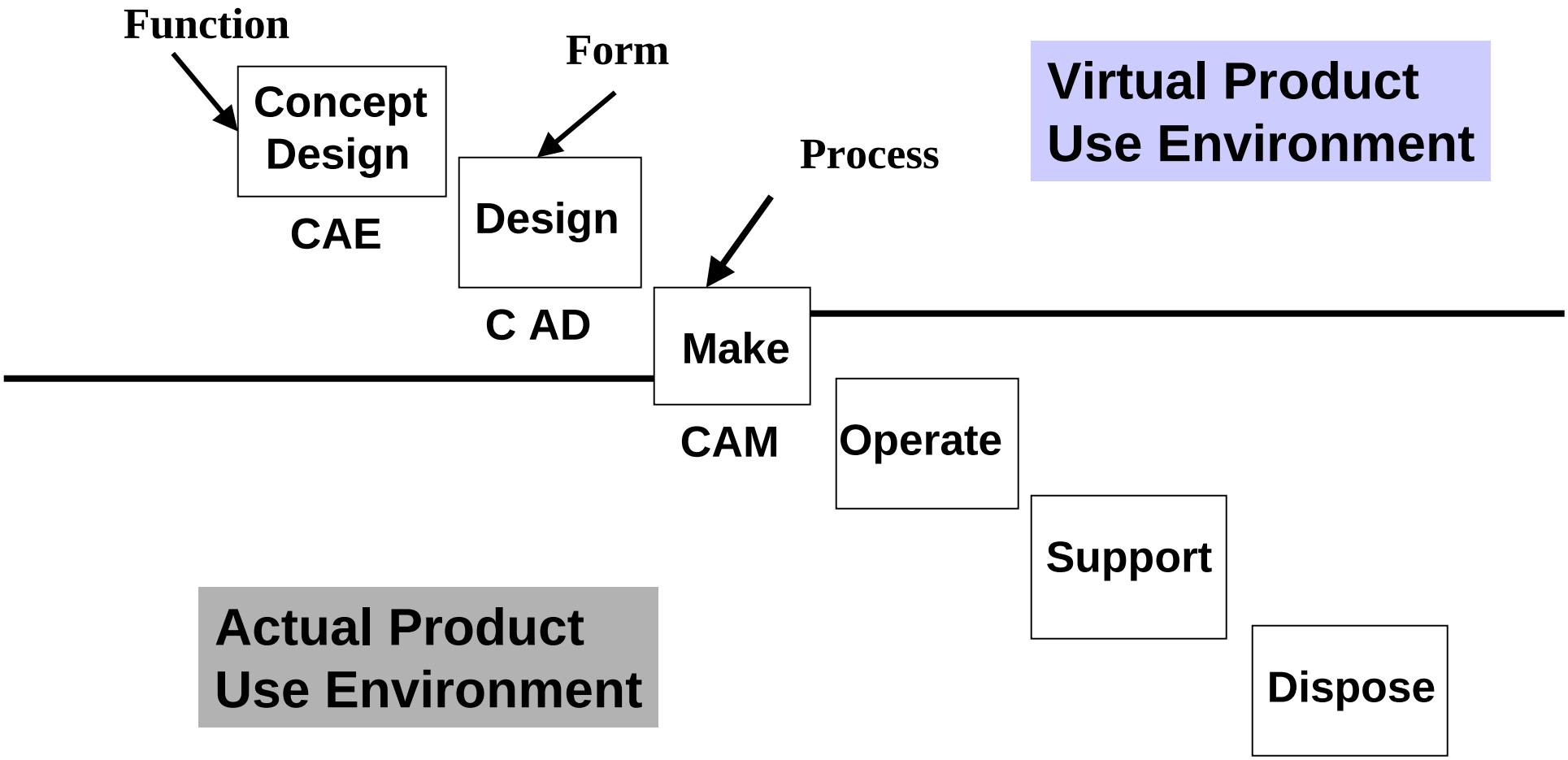
- Key processes
  - So many people are served so quickly
  - Replicate the experience for many restaurants

- Hamburger University
  - 30 faculty
  - 50,000 manager graduates
  - 22 languages
  - also 10 international centers

The Importance of Process

- Do the processes still provide value?
- Opening day in Kuwait City, Kuwait, 1994
  - 15,000 customers
  - drive-thru line was 7 miles long
- *Was the appeal the food or the process (the experience)?*

IDEALIZED PRODUCT LIFE CYCLE



An ISO Industrial Framework Model

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System Analysis Challenges

- **Conceptual Design**
  - **Functional Design Requirements, Affordability**
- **Preliminary Design**
  - **Product Performance and Life Cycle Requirements**
- **Design**
  - **Component Geometry, Bill of Materials , Assembly, Maintainability, Reparability, Affordability, etc.**
- **Make**
  - **Processes; Forming, Joining, Surface Finish, etc.**

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Moving CAE Up Front

FUTURE Applications: Early in Design Cycle

ROBUST DESIGN:

Generic Designs
Parameterized Math Models
Robust Design Processes
Virtual Product Performance
Thousands of Design Scans
Robust Design Alternatives

LEGACY Applications: Late in Design Cycle

DESIGN VERIFICATION:

Specific Designs
Numeric Data Models
Smart Engineers
Actual Product Performance
Archive Certification Results
Final Design Safety Margins

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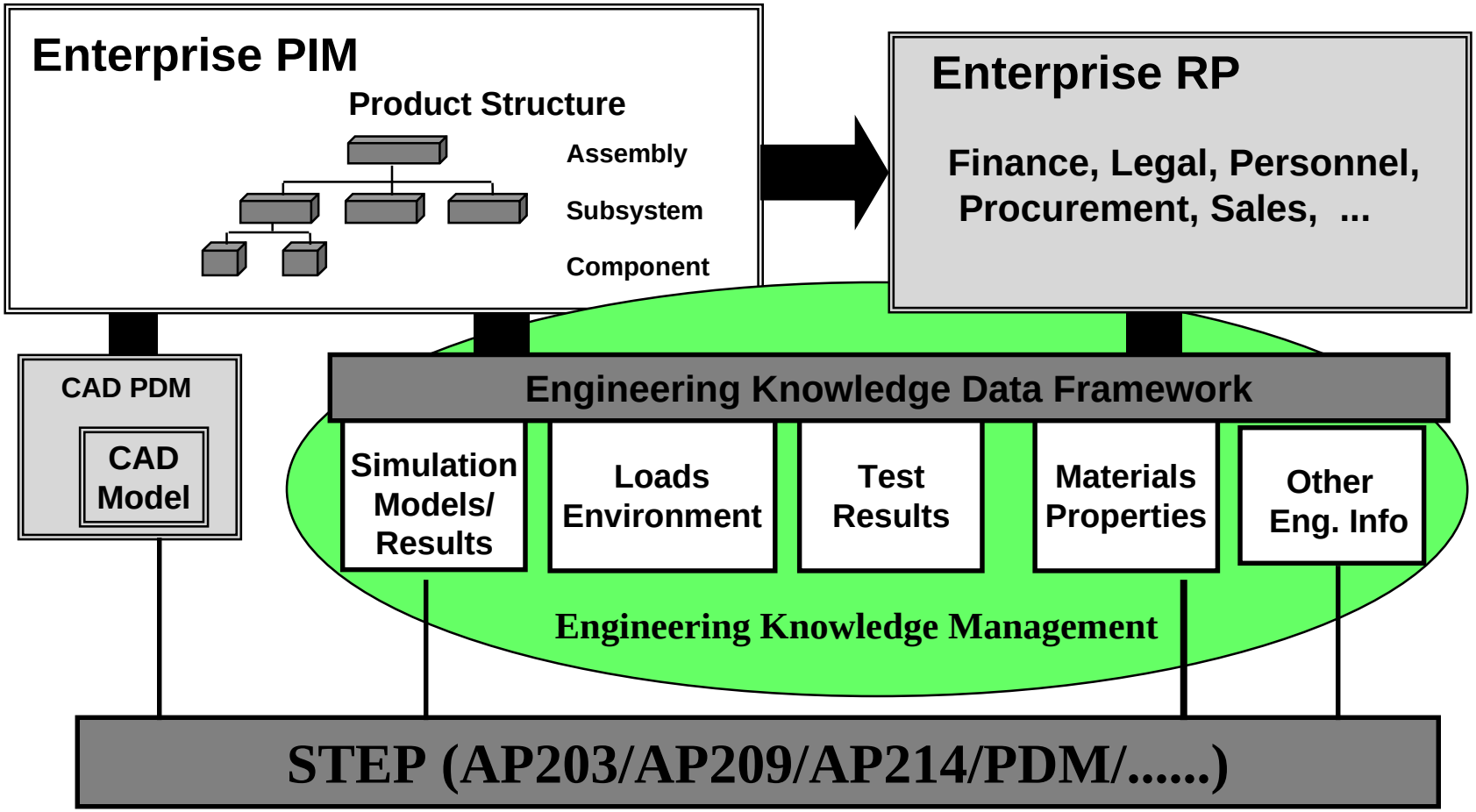
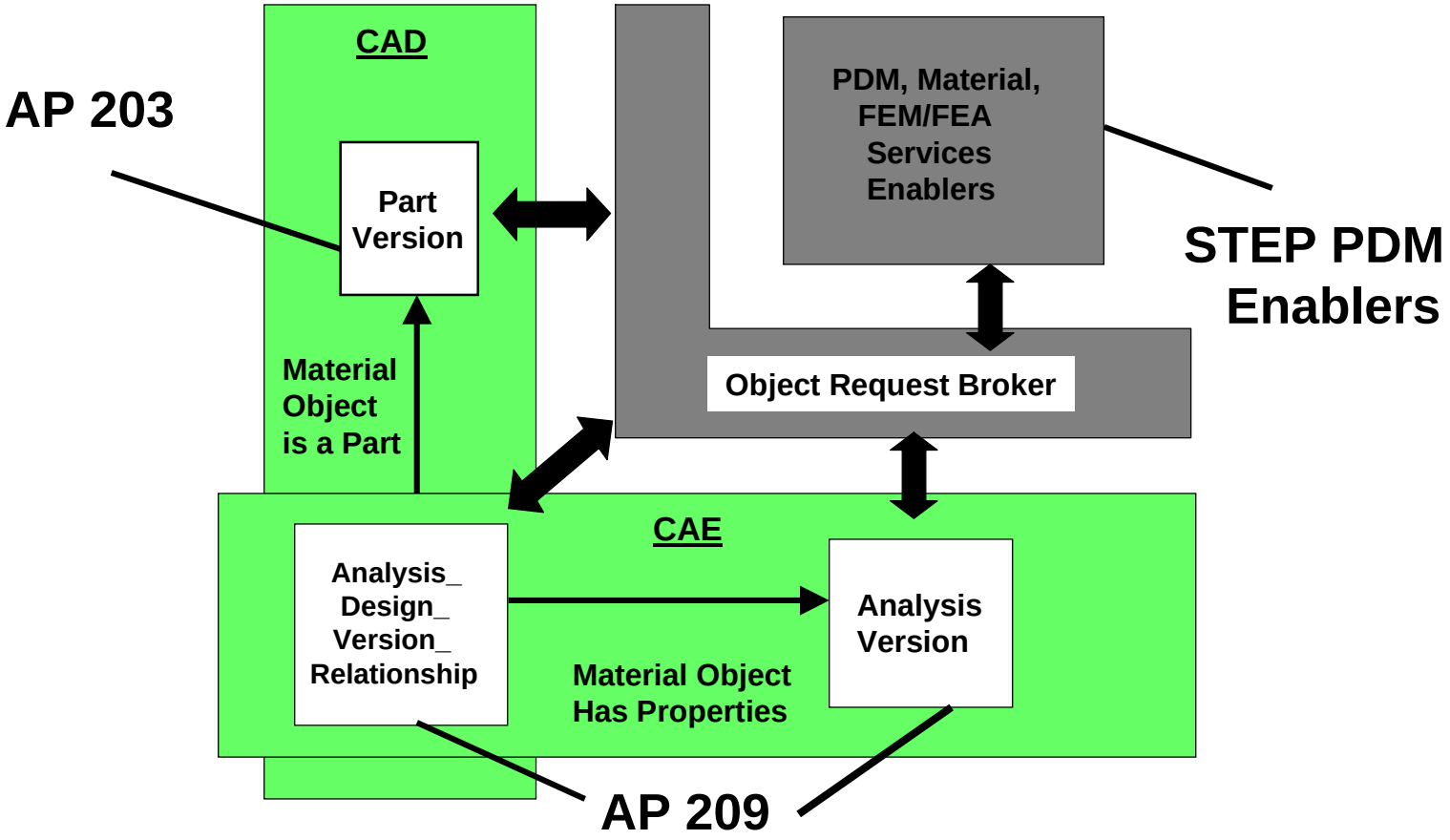
CAE Software Technology Challenges

- Analysis Up Front in the Design Process
- CAE/CAD/CAM/PDM Interoperability
- Web Integrated Design-Build Teams
- Multidisciplinary Design Environments
- Robust Design Culture Challenges

Enterprise Wide Product Data Management



ISO/STEP Product Data Interoperability



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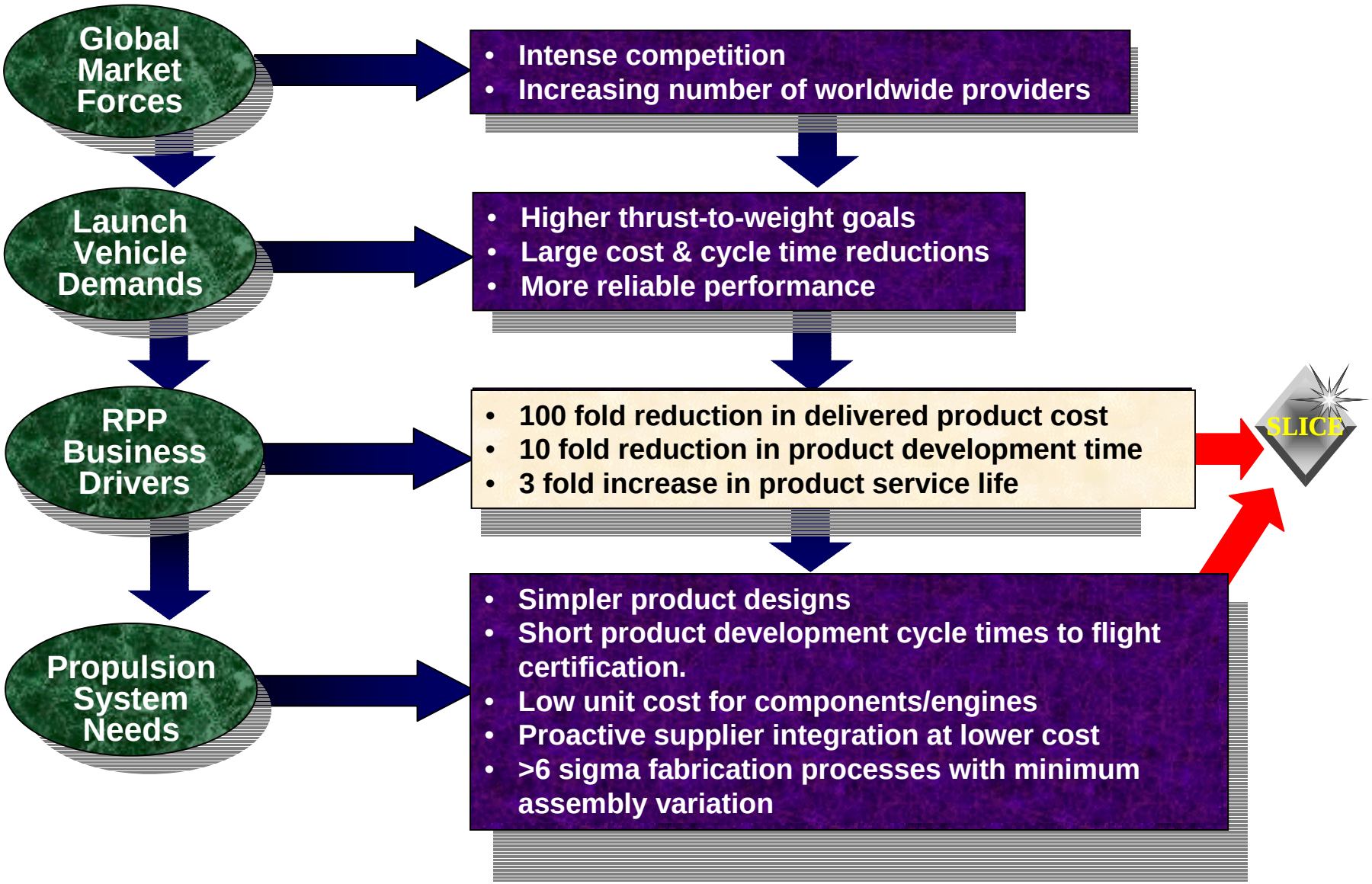
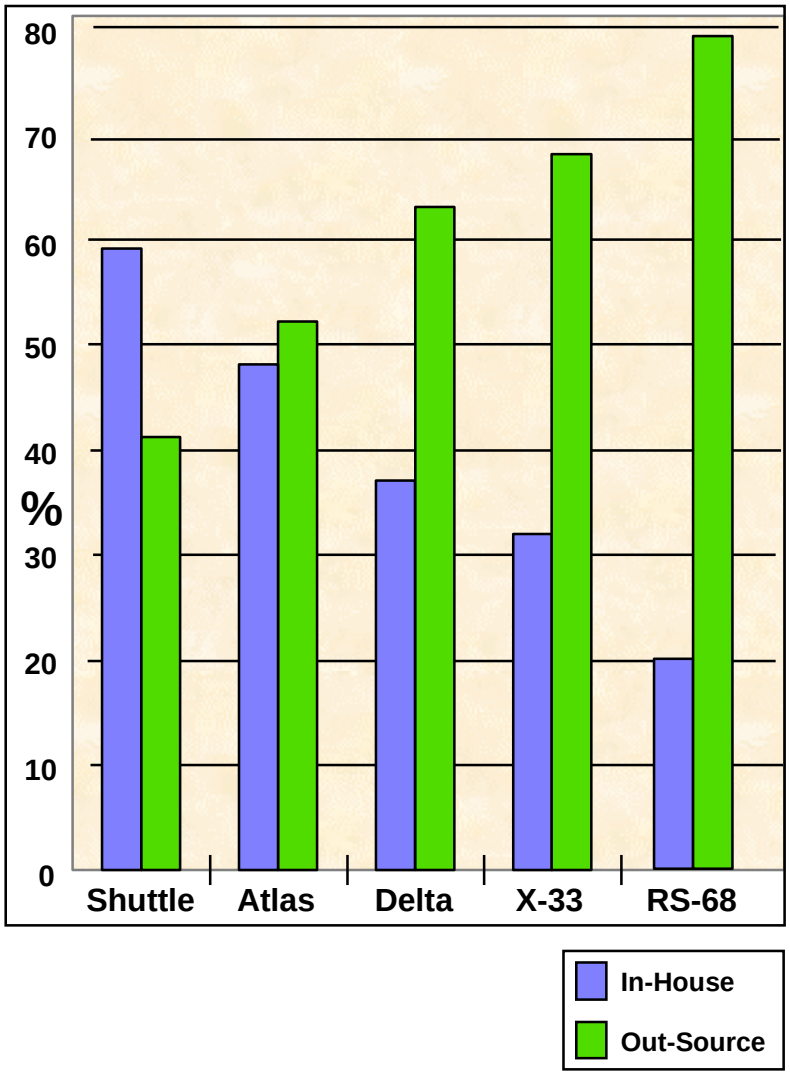
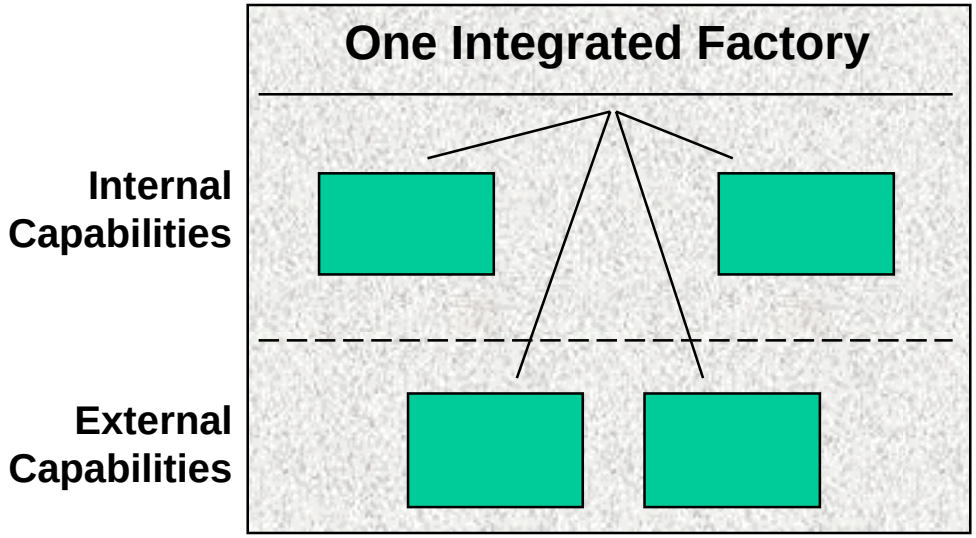
Propulsion Business



RPP Increased Need for Suppliers Requires An Enterprise Vision



Vision



Extended

- PDM
- MRP
- Flows/capacity Planning
- Scheduling

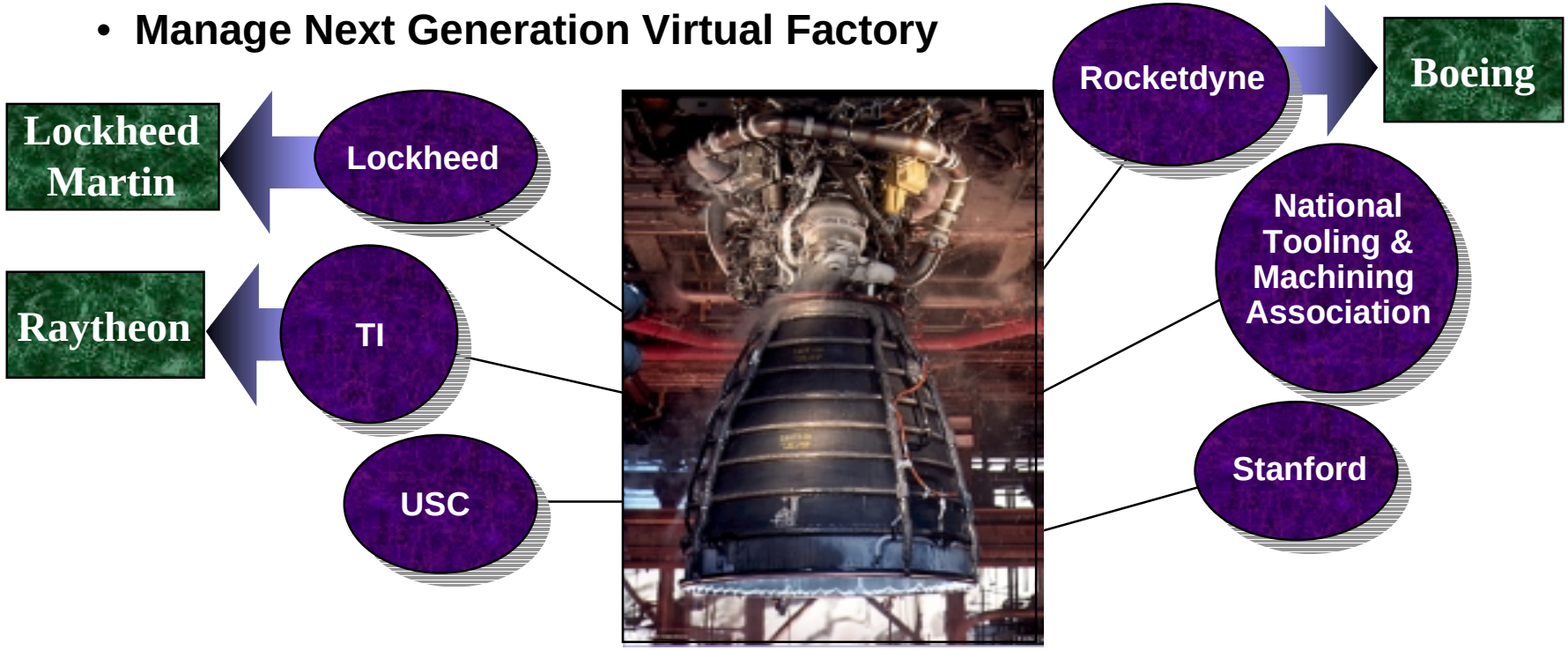
Tomorrow's' Factory Integrates The Supplier Base As If They Were Merely Another Department

Agile Infrastructure for Manufacturing Systems

AIMS

DARPA

- Support Design Anywhere, Buy Anywhere, Build Anywhere Concept
- Support Development of Enabling Technologies and Business Systems to
  - Rapidly Form Partnerships (Virtual Corporations)
  - Execute Virtually Collocated IPPD Activities Involving Multi-Tier Supply Chains
  - Manage Next Generation Virtual Factory

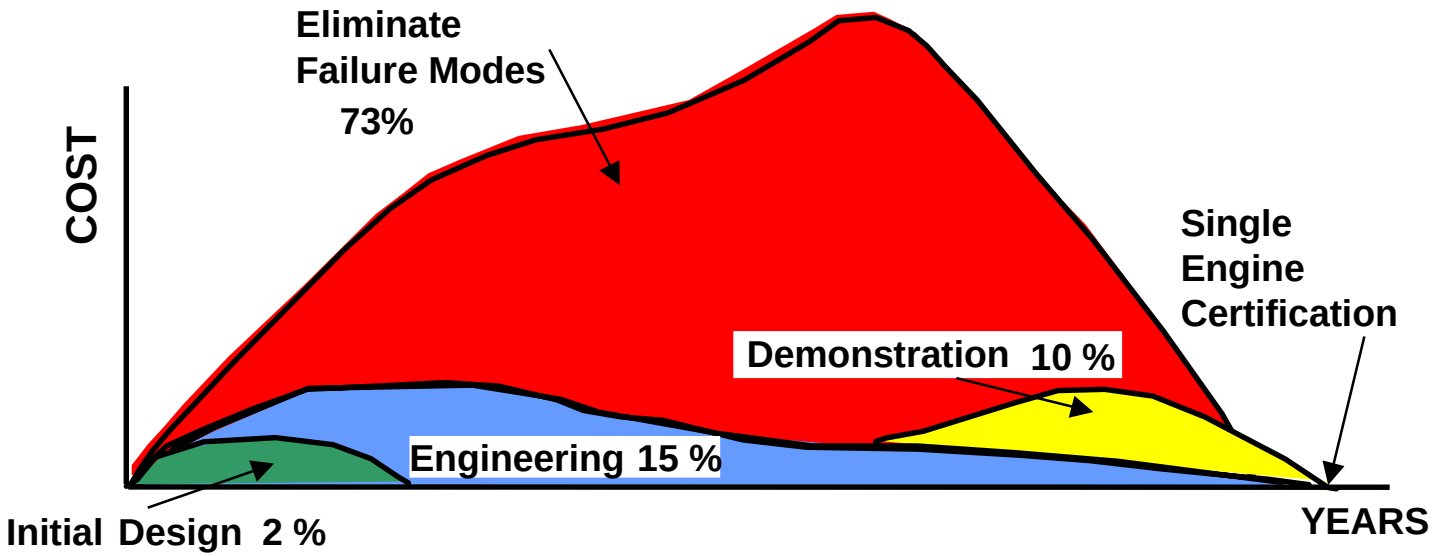


Demo 2 Team Member Locations

Aims Demo 2 Product

Parameter	Conventional Design	Present SLICE Design
# of Parts	100s	6
Producibility	2-4 Sigma	9 Sigma
1st Unit Cost	$ M	$ 50 K
Prod. Unit Cost	$ M	$ 35 K
Design Effort	6-7 Man Years	<1 Man Year
Design Schedule	2 Years	9 Months
Level of Combustion Analysis	High	Poor

Cost to First Production Engine Dominated by Eliminating Failure Modes

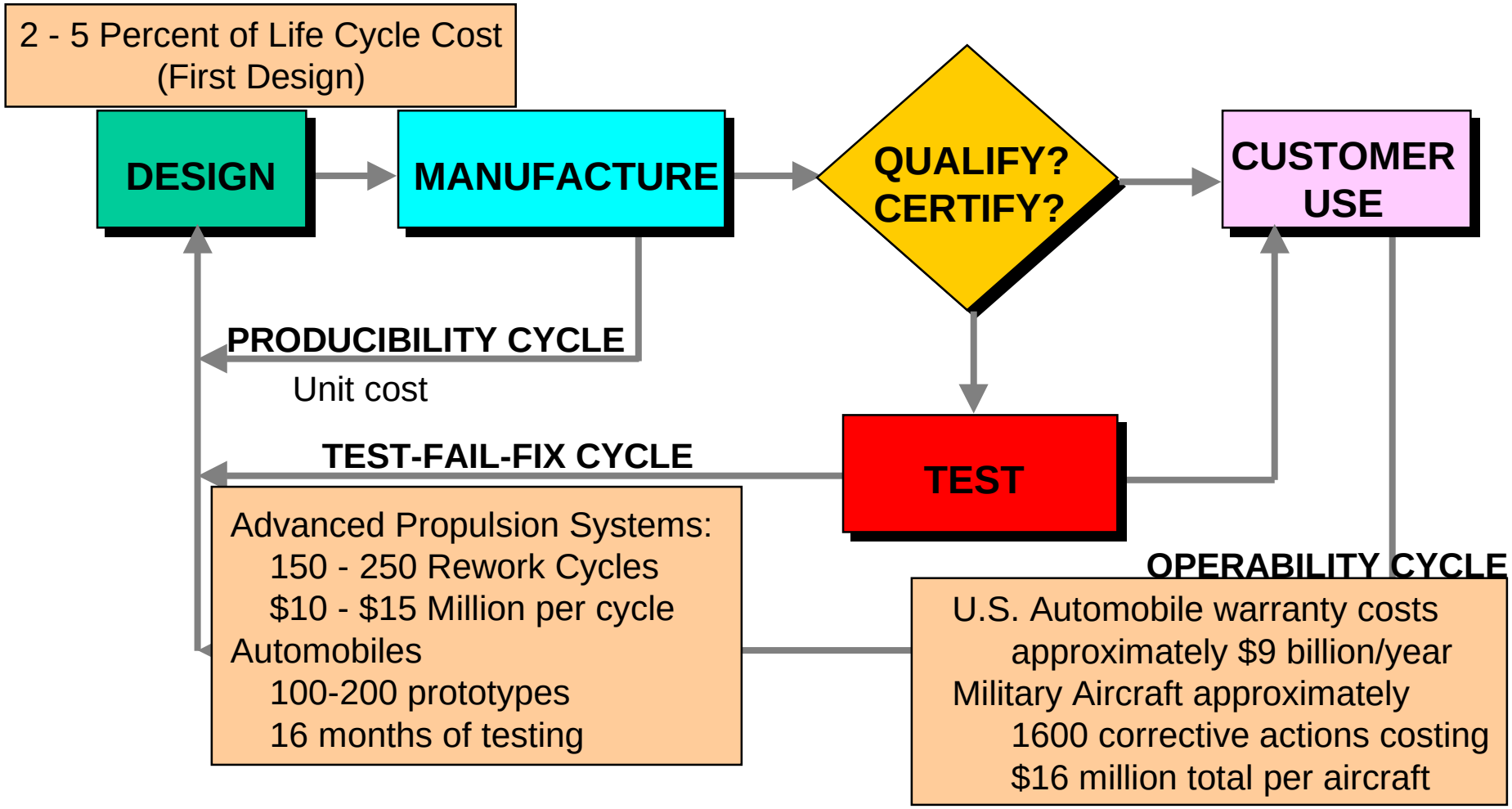


Examples of Nonrecurring Development Costs

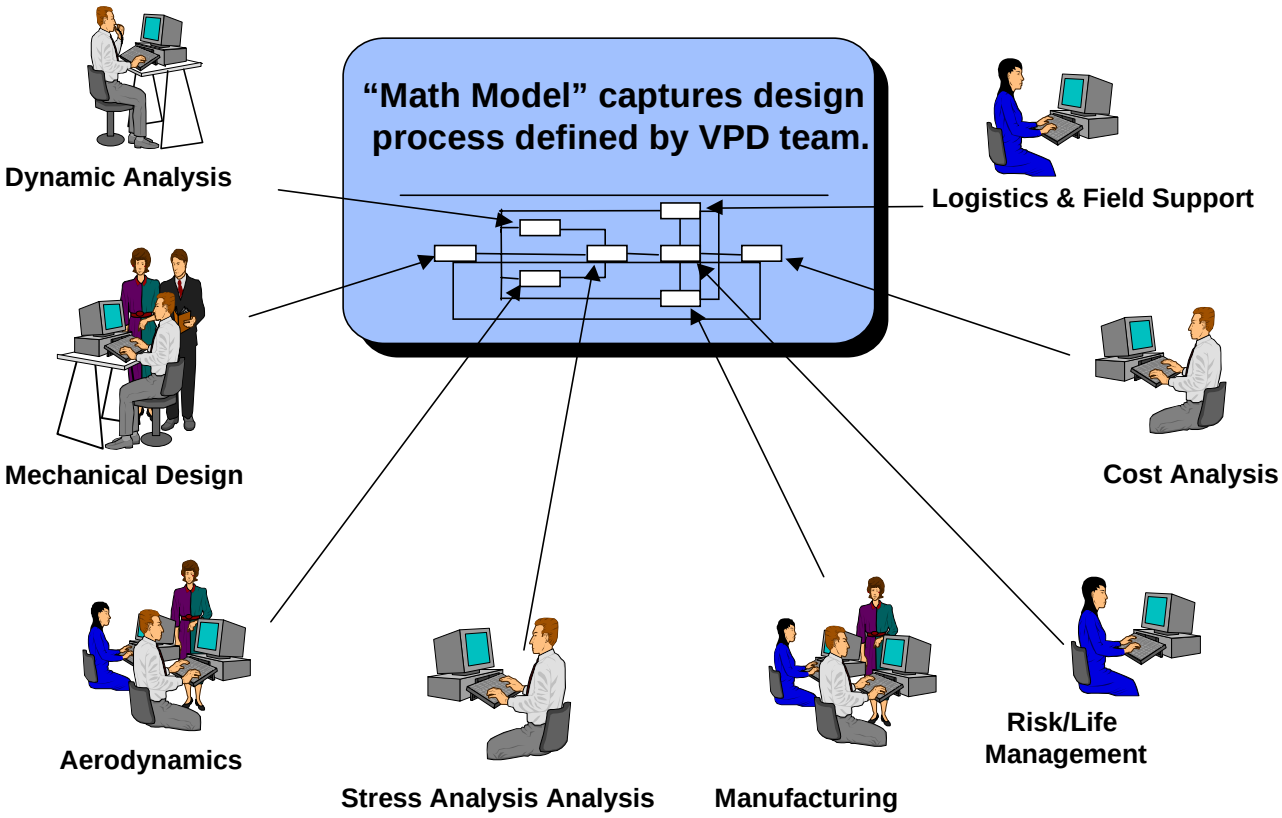
Rocket Engines	
• SSME	$ 2.8 B
• F-1	$ 2.4 B
• J-2	$ 1.7 B
Jet Engines	
• F-100	$ 2.0 B
Automobiles	
• 1996 Ford Taurus	$ 2.8 B

SIMPLIFIED PRODUCT DEVELOPMENT PROCESS

(EXAMPLES SHOWING SIGNIFICANCE OF REWORK LOOPS)



A Robust Design System



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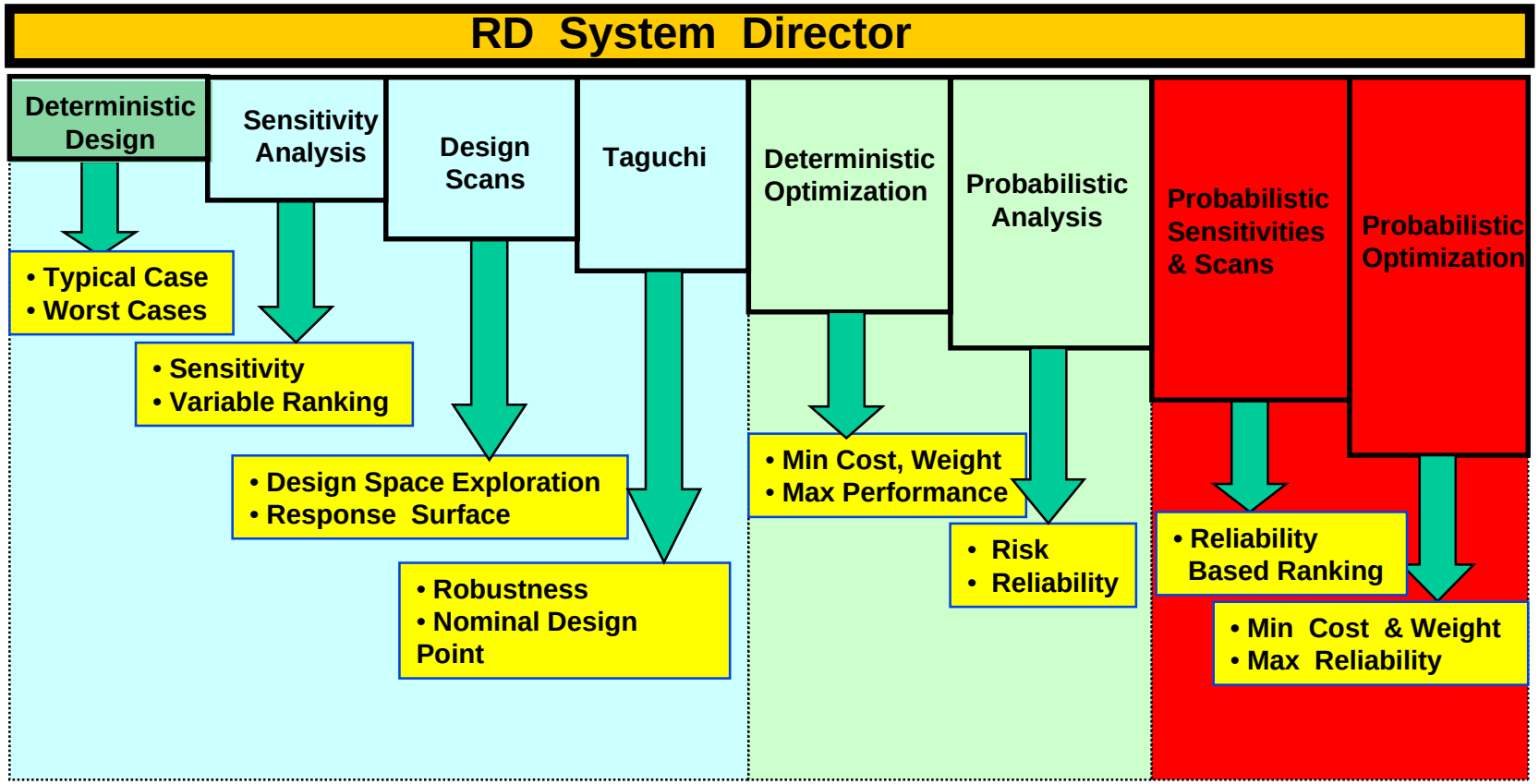
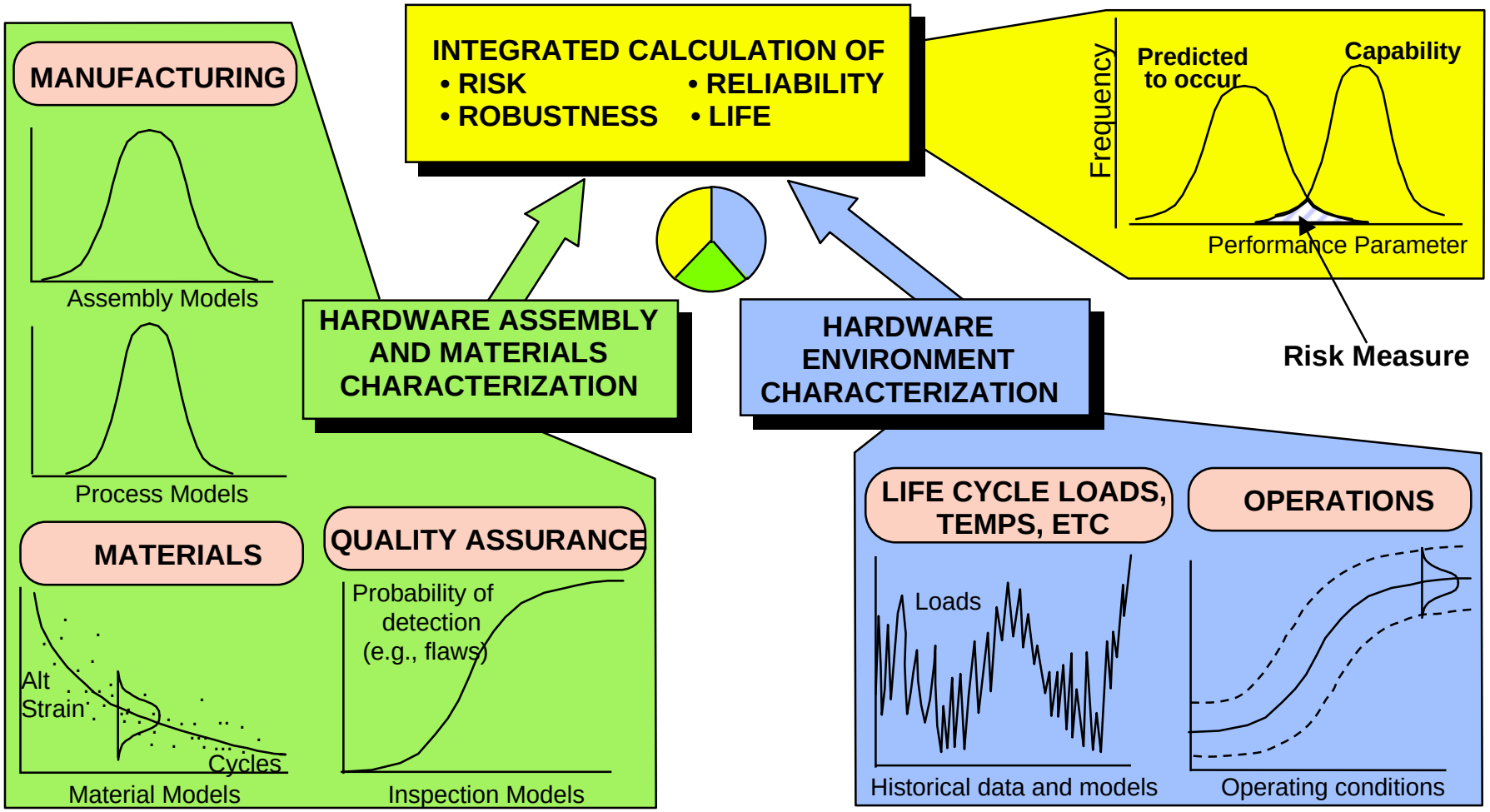
Robust Design Provides Design Tools to Match Needed Level of Analysis



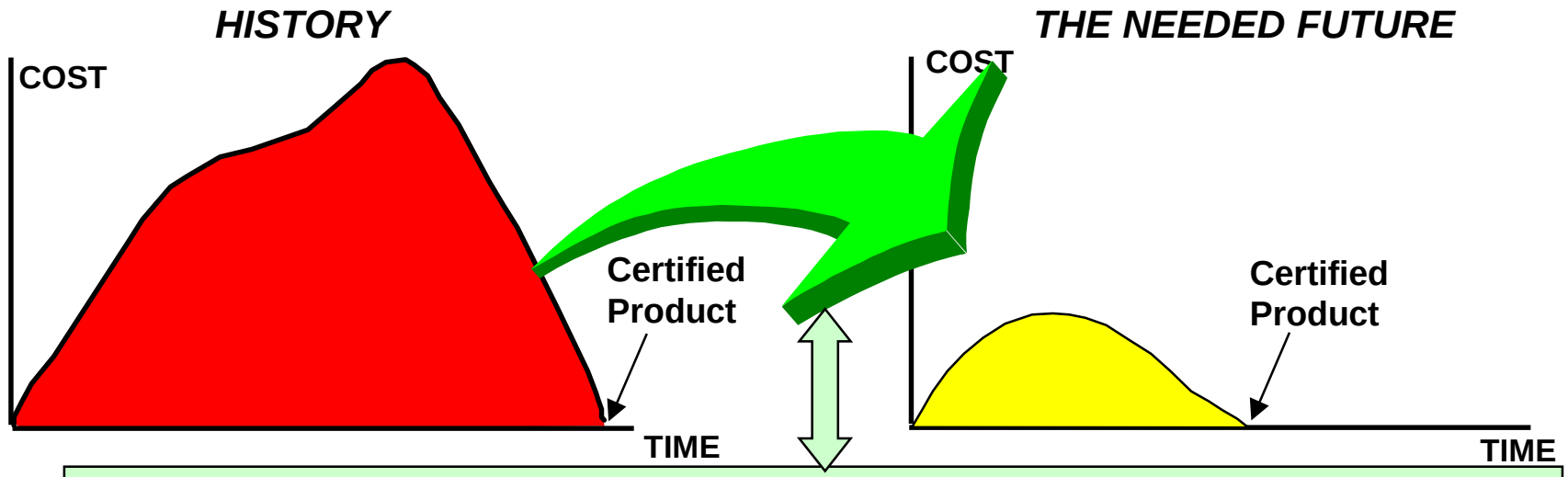
RDCS -- Design Cycle Capability for Life Cycle Variability

Attacks Fundamental Causes of Failure Modes



Robust Design Computational System (RDCS)

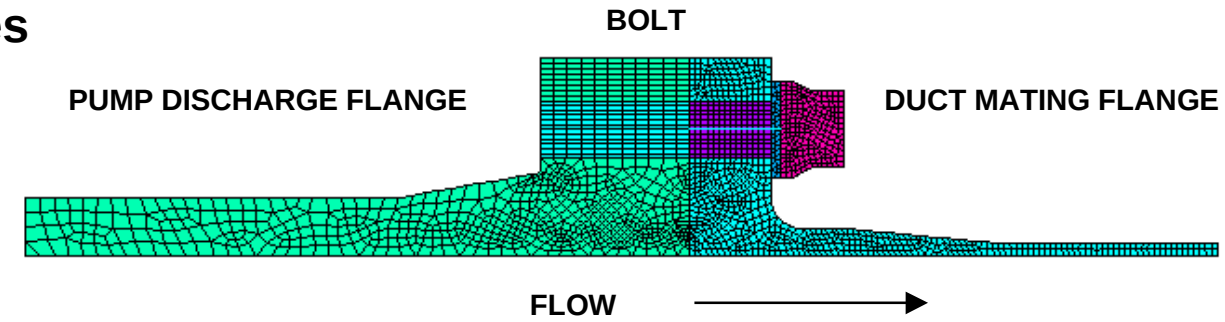
Capabilities Needed to Reduce Cost of Test-Fail-Fix by a Factor of 4



- **Risk, reliability, robustness must be design parameters**
  - Requires accounting for uncertainties/variabilities
- **Design team must understand design space (via parametrics)**
  - Multiple design alternatives characterize design space
- **Results must be provided quickly to support design decisions**
  - Complex calculations required for each design alternative
- **System must be used by typical integrated product teams**
  - User friendliness needed for ease of performing analyses and interpreting results
  - Insulate users from complexities of analyses

Discharge Joint Analysis
Demonstrated Productivity Improvement

- Identify Key Sensitivities
  - 11 Independent Variables
  - 22 Design Points



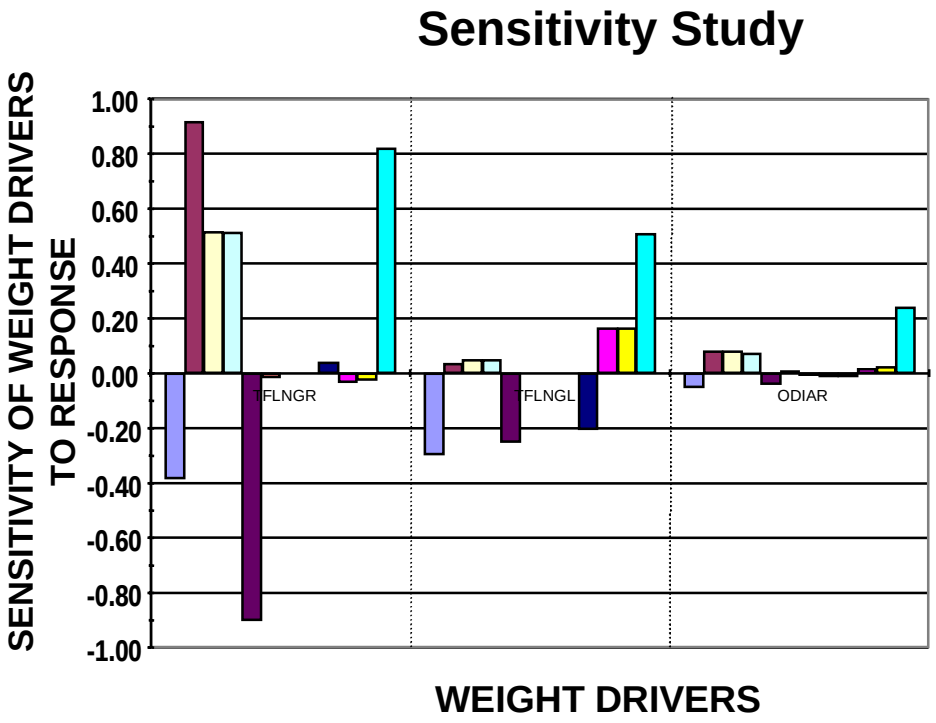
- Design Space Explorations
  - 11 Independent Variables
  - 4 Scan Points for Each
  - 44 Design Points

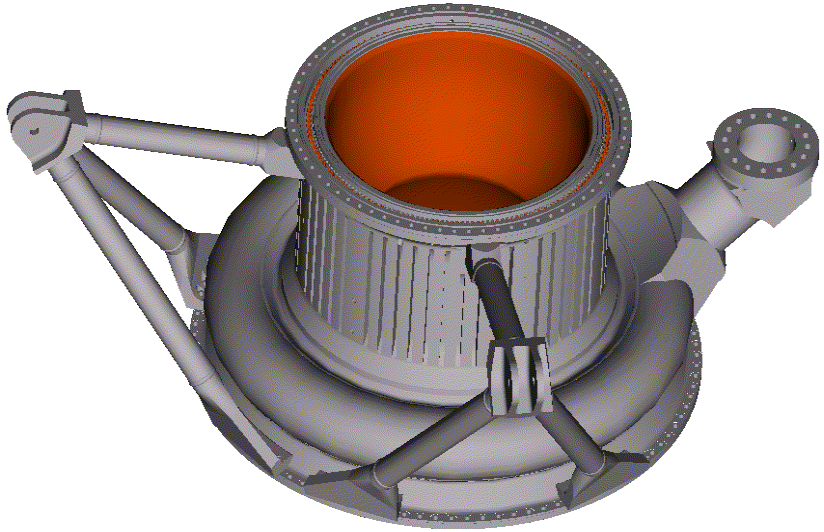
- Taguchi Analysis for Robustness
  - 7 Control Values at Three Levels
  - 4 Noise Values at Two Levels
  - 232 Design Point Solutions

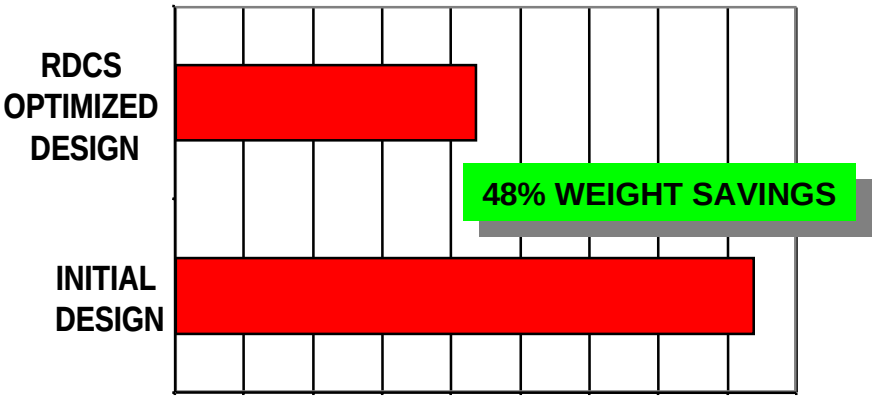
Analyst's Time Reduced by 1 to 2 Orders of Magnitude

- Sensitivity and Design Scan - Overnight
- Taguchi Analysis - Overnight

RDCS Used To Reduce Weight







Robust Design Challenge

Find a product design that
maximizes expected performance
for a given of cost and *risk*
over the entire amount product life cycle.

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Keys to Expanding Use of IT

- ❑ Vision
- ❑ Process Understanding
- ❑ Empowerment
- ❑ Teaming

Future Virtual Enterprise Business

Virtually collocated teams of companies and personnel representing the best world-wide capabilities available at the time, independent of organizational affiliation, working together electronically at least as efficiently as a fully collocated team within one company

Design

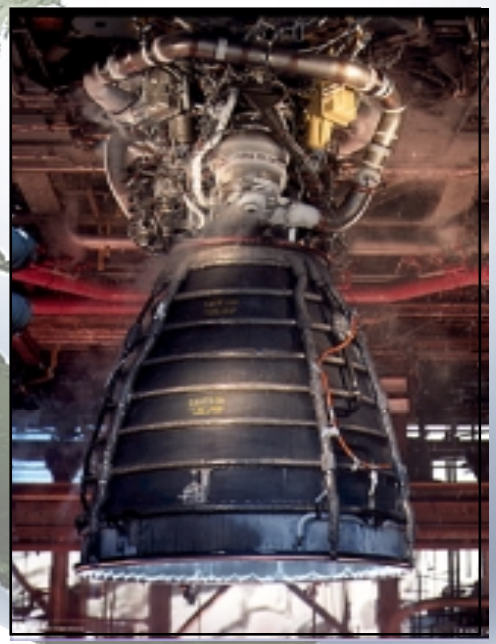
Suppliers

Analysis

Customers

Manufacturing

Test



Operations

Risk/Life Management

INFORMATION HYPERFLOW

Five Emerging Business Upheavals
Hyperflow: low cost, zero latency, and rich content, easy access via Internet

•**Business Velocity** Speeds Up
- Order-to-ship cycle time at new levels - e.g., Dell
- Transfer of complex content instantaneously - e.g., PP soft copy

•Surge in **Buyer Power**
-Buyers are leveraging extended access to make smarter choices
- Sellers must create a presence, but can leverage access too

•Extending **Decision Making**
- Decisions at the point-of-action can be made by all employees based on Intranet-delivered information such as profitability by each customer

•Accelerated **Business Process Outsourcing**
-Administrative functions such as accounting can now be out-sourced to specialist for performance and cost benefits

•Leveraging via **Knowledge Management**
-Sharing of intellectual capital to outperform competition
-Gaining loyalty of customers via useful information/Knowledge access

NEED TO UNDERSTAND:

1) BUSINESS PROCESSES

- END-USER
- TECHNOLOGY DEVELOPER
- TECHNOLOGY SUPPLIER
- NON-PROFIT
- GOVERNMENT

2) TECHNOLOGY PROCESSES

- ELECRONICS (PWB EXAMPLE)
- MECHANICAL (DESIGN-BUILD PROCESS)
- PROCESS INDUSTRY (NUCLEAR POWER)

PROCESS LEARNING GUIDE

START WITH:

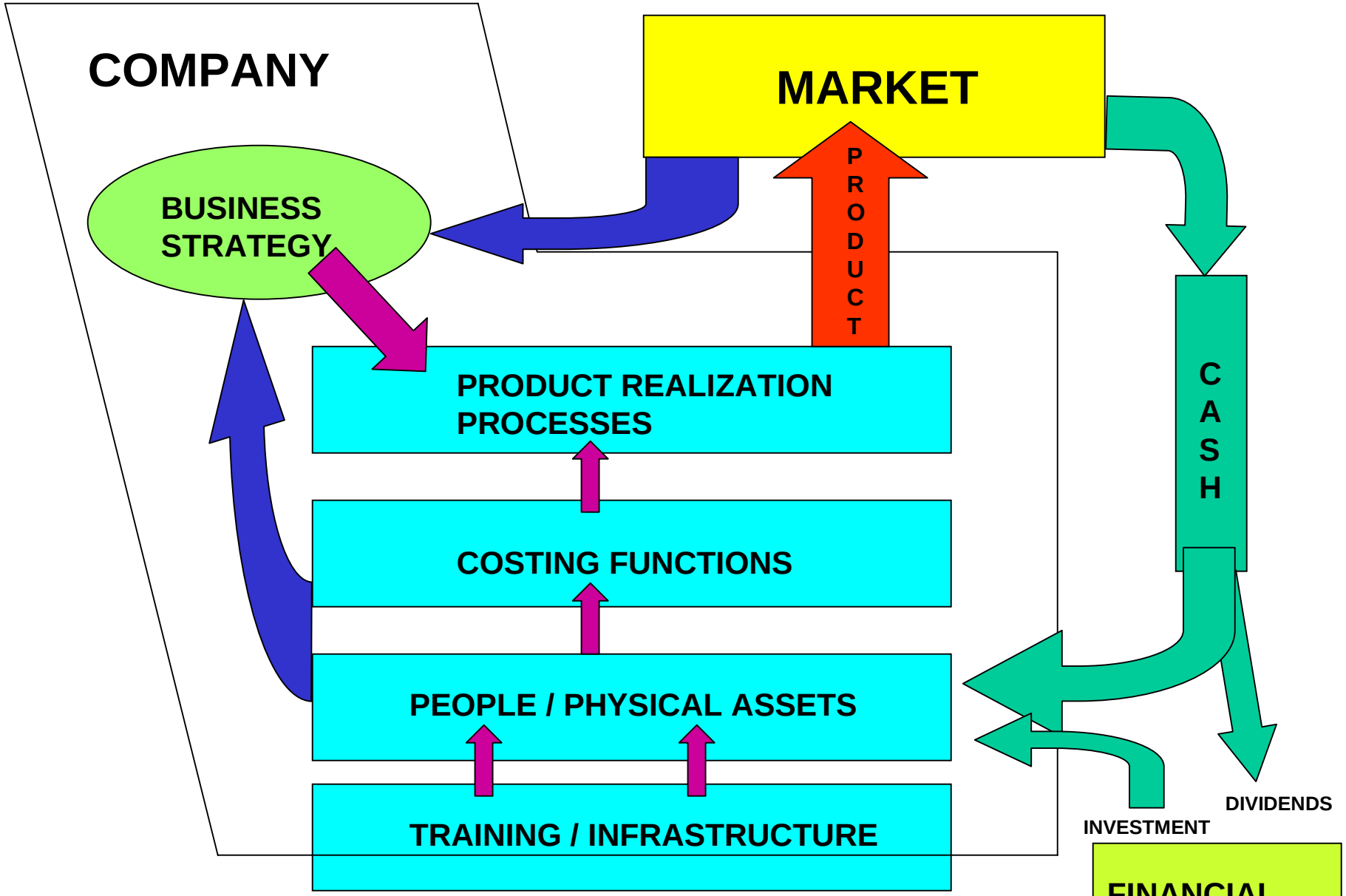
- HIGH LEVEL BUSINESS OBJECTIVE OF COMPANY/ORGANIZATION
- IN SINGLE SENTENCE

IDENTIFY:

- PROCESSES COMPANY USES TO MEET OBJECTIVE
- SUPPORTING BUSINESS PROCESSES
- TECHNICAL PROCESSES
- HOW DO PRESENT PROCESSES NEED TO CHANGE

GENERAL RULE:

- MAXIMIZE INFORMATION WITH FEWEST WORDS
- USE AS A COMMUNICATION TOOL



Generic Manufacturing Enterprise

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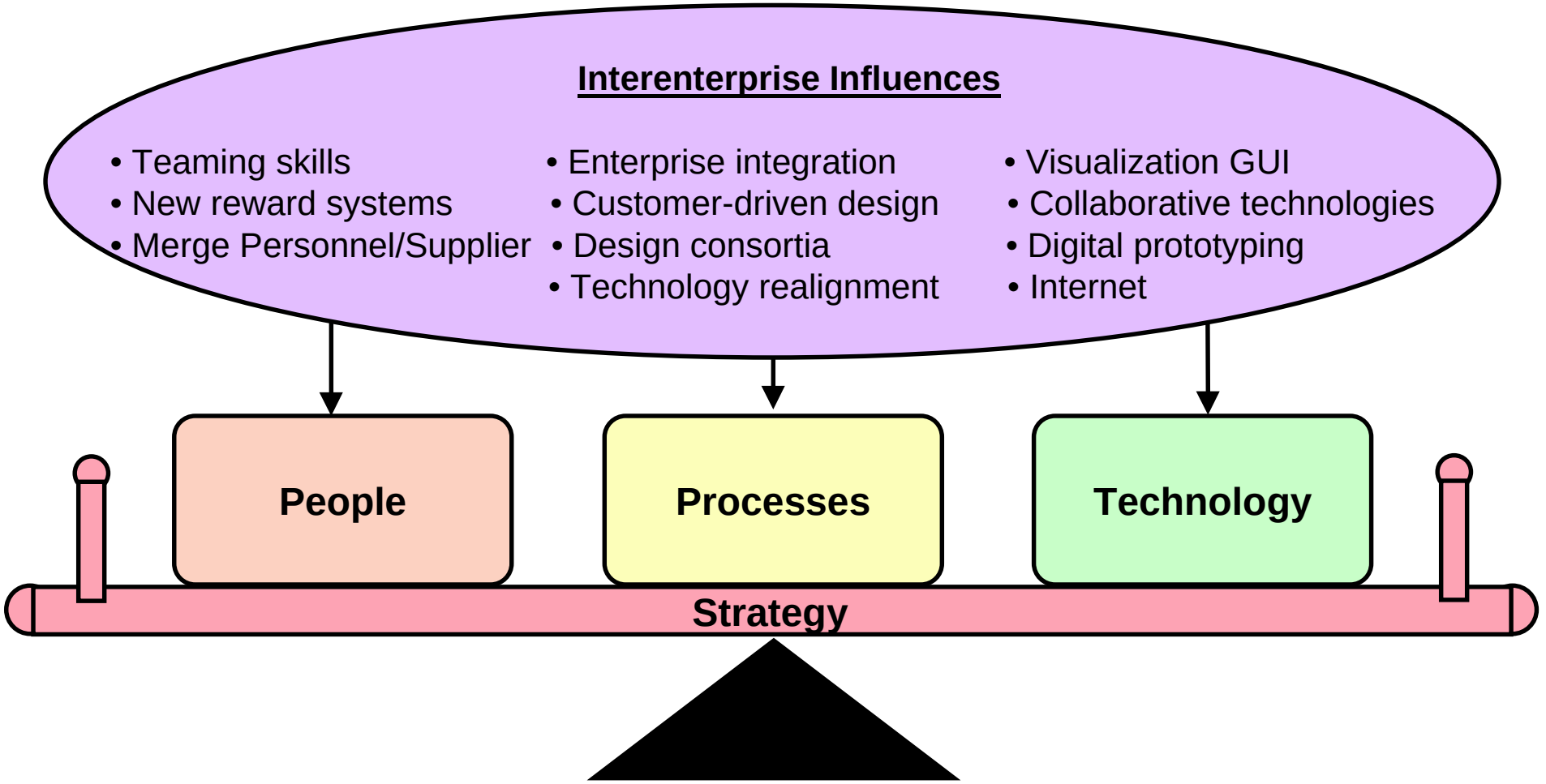
Potential IT Empowerment Capability

- ❑ Easy to Use Tools
- ❑ WEB Access to Information
- ❑ Decision Support Tools

Extending Global Engineering Competitiveness Across the Supply Chain

Effective implementation of this next generation will require that people, processes and technologies be bought into balance and alignment



Whaling Industry Example for Future Business Model

- Two New England City Captured & Maintained >90% Market Share for >100 Years
- Operations Procedure Dominated Keys to Competitive Advantage - Model
  - No mission had same crew (shared IP)
  - Whale oil went to whale bone (Innovation & Entrepreneurship) after first 50 years due to heating fuel
  - Compensation by shares in mission profit where number of shares was based upon vital nature of skills to mission success (Fire Department except no pay if unsuccessful)

Could Compensation for Potential Rather Than Real Contributions Work for Us?

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TECHNOLOGIST TEAM ROLE

- **Ensure WIN-WIN**
  - **Requires understanding each participant's objectives/processes**
- **Make Technology Easy-To-Use**
- **Sharing Knowledge**